Cognitive Ethology of Rhesus Macaques (*Macaca mulatta*) in Urban Areas of the Semi-Arid Zone of Uttar Pradesh

SYNOPSIS

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In

ZOOLOGY

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1. Introduction

The Rhesus macaque (*Macaca mulatta*) belongs to the *fascicularis* macaque lineage, which occupies the broadest and most continuous distribution of the macaque species (Fooden, 1982). It is one of the best known species of Old World Monkeys. Endemic to Central, South & S.E. Asia, Rhesus macaques are the most successful primate species other than humans, partially due to their high dietary plasticity. Classified as omnivores, they feed on a number of plant species, plant parts, eggs and small animals, both invertebrates and vertebrates (Alvarez-Romero & Medellin, 2005). They are also categorized as food generalists, which allows them greater dietary flexibility and contributes to their success in disturbed forest habitats and urban environments (Richard, Goldstein & Dewar, 1989)

Currently, there are three known semi-free or free ranging Rhesus macaque populations that exist outside their native range, all of which are in Neotropics:

1) Cayo Santiago, Puerto Rico
2) Morgan Island, South Carolina
3) Silver Springs Park, Florida

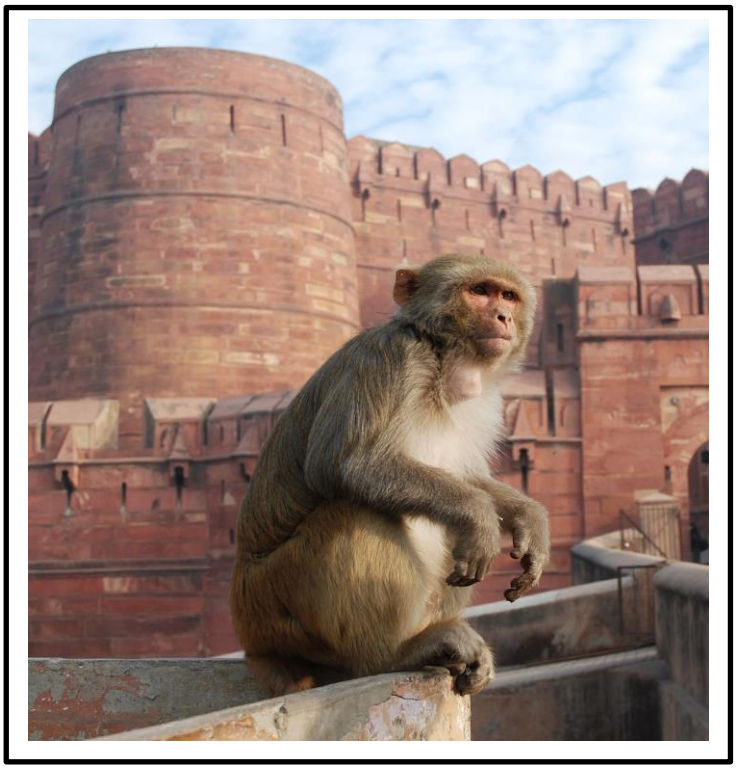


Plate-1 *Macaca mulatta*

1.1 Systematic position

Kingdom- Animalia

Phylum- Chordata

Class- Mammalia

Order- Primates

Family- Cercopithecidae

Genus- *Macaca*

Species-*mulatta*

1.2 Habitat and Distribution

Rhesus macaques occur throughout most of southern Asia, in northern and central India, eastern Afghanistan, Bangladesh, Bhutan, central and southern China, Lao PDR, Myanmar, Nepal, Northern Pakistan, northern Thailand and Vietnam (Groves, 2001). In India, they are found from 4,000m altitude in the Himalayas to the sea level in Sunderbans and in the south, up to the river Godavari (GISD, 2015).

1.3 Habit

They are diurnal and omnivorous, adapted to a variety of habitats occupying both arboreal and terrestrial niches including the deserts of Rajasthan, the tropical forests of south eastern Asia, agricultural plains of the Gangetic basin, temperate pine forests of the Himalayas and the rugged mountains of north central China. They are intelligent, excellent swimmers, social and gregarious, most adaptable and learn to live among humans and domestic animals, if tolerated. They are aggressive, territorial and attack in groups whenever they feel threatened (Alvarez-Romero & Medellin, 2005).

1.4 Conservation status

Listed as **Least Concern** in the IUCN Red List of Threatened Species in view of their wide distribution, presumed large populations, and tolerance of a broad range of habitats. This species is listed on CITES Appendix II. It is protected under Scheduled III of the Wildlife Protection Act.

Activities like deforestation and urbanization due to human population growth have provoked the populations of monkeys to move towards urban areas. This has compromised with the necessary conditions for their survival, leading to changes in their behavior (Begnoche, 2014). Rhesus macaques have been reported to be in conflict with humans as well as other species (Chauhan and Pirta, 2010). *Macaca mulatta* may be carrier for transmitting many communicable diseases like herpes B virus, skin disease, diarrhea and rabies (Imam and Ahmad, 2013).

Semi-Arid zone is a disturbed habitat where an increase in mean maximum and minimum surface air temperature of 0.7^0 C and 1^0 C over land has been anticipated due to emissions of CO_2 (mainly from burning coal, oil and natural gas), methane and nitrous oxide (from agriculture sector) and long-lived industrial gases viz; CFCs, HFCs and PFCs which have also increased air pollution . Agricultural activities have been emitting 33% of methane of the total greenhouse gases in this zone. It has been facing very unpredictable weather for last few years and extreme temperature range of near zero to 48^0 C. Every third year, the zone has faced dry spell in 6 out of last 10 years leading to paucity of surface water (Uttar Pradesh State Action Plan on Climate Change, 2014). Rhesus macaques have an affinity towards disturbed habitats, as reported by Barret *et al.* (2019) and therefore, their populations and hence their menace have been consistently increasing in semi-arid zone, as reported in numerous newspaper articles in recent years.

Cognitive Ethology, coined by Griffin (1980), deals with the versatile thinking by non-humans and how their behavioral data obtained can be used to examine the evolution and origin of human cognition. It is inclusive research and examines how and why an animal chooses to behave in a particular way, why their choice varies with environmental context, how conspecifics interact and respond and how other species respond to their behavior. Cognition and conscious thinking by non-human animals present a variety of exciting and significant research challenges for scientists concerned with human behavior (Griffin, 1984; Roitblat, 1987) , animal welfare, conservation and management (Bekoff, 2017; Griffin, 2013; Rendall, 2013). Therefore, the present study has been designed to use the cognitive ethology approach for analyzing the behavior of Rhesus macaques in urban areas of the semi-arid climatic zone of UP.

2. Review of Literature

2.1 International status

Hinde and Rowell (1962) explained the communication by posture and facial expression of *Macaca mulatta* in Great Britain. Fooden (1982) explained the eco-geographic segregation of Macaque species. Griffin (1984) elucidated how animals think and what they want. Roitblat (1987) introduced comprehensive data to thinking, information processing, and memory in animals that explored the representation of objects, concepts and the psychological processes that generate and respond to these representatives. Richard *et al*. (1989) studied the feeding ecology of macaques in Murree Hills of Northwestern Pakistan. Groves (2001) explained the geographical distribution of Macaca mulatta. Alvarez *et al*. (2005) explained exotic diversity, distribution and potential effect of *Macaca mulatta* in Mexico. Fuentes (2006) explained Human-Nonhuman primate interconnections and their relevance to anthropology. Fuentes *et al*. (2008) assessed human-macaque interactions in Singapore. Timmins *et al*. (2008) reported general information about *Macaca mulatta* in IUCN Red List of Threatened Species. Chang *et al*. (2012) analysed that inhaled oxytocin amplifies both vicarious reinforcement and self-reinforcement in experimental Rhesus macaques in Durham, NC. Griffin (2013) revealed cognitive abilities by nonhuman animals present a variety of exciting and significant challenges. Rendall (2013) studied cognitive ethology in non-human species. Begnoche (2014) studied the effect of construction activity on the behavior of captive Rhesus macaques At the University of Massachusetts,Amherst. Canteloup *et al*. (2015) explained intentional gestural communication and discrimination of human attentional states in Rhesus Macaques in France. GISD (2015) provided current profile on species *Macaca mulatta*. Riley and Wade (2016) reported the population status and feeding behavior of the Silver River Rhesus Macaques and their interaction with humans. Simpson *et al*. (2017) revealed that handling captive born and raised monkeys alters later exploratory, cognitive and social behaviors in USA. Bekoff (2017) explained how cognitive ethology helps in comparative, evolutionary

and ecological study of nonhuman minds. Barrett *et al.* (2019) reviewed the cognition of nuisance species and problem individuals to shed light on the struggles of coexistence with humans along disturbed landscapes. Kaburu *et al.* (2019) reported that Human-Rhesus macaque interactions affect grooming behavior of macaques in Shimla.

2.2 National status

Malik *et al.* (1984) studied population growth of free-ranging Rhesus monkeys at Tughlaqabad. Malik *et al.* (1985) analyzed group fission in free-ranging Rhesus monkeys of Tughlaqabad. Malik (1989) studied population growth and stabilizing age structure of the Tughlaqabad Rhesus monkey. Johnson *et al.* (1991) studied age and dominance-related variation in feeding time among free-ranging female Rhesus monkeys of Tughlaqabad. Malik and Johnson (1994) revealed the need and the cost of of translocation of commensal Rhesus monkey in India. Johnson *et al.* (1998) quantified suckling intensity in *Macaca mulatta*. Imam *et al.* (2002) reported mass translocation of commensal Rhesus monkeys in Vrindavan, U.P. Medhi *et al.* (2007) estimated status and diversity of temple primates in Northeast India. Chauhan and Pirta (2010) reported agonistic interaction between humans and two species of monkeys (Rhesus Monkey and Hanuman Langur) in Shimla Himachal Pradesh. Pragatheesh (2011) studied the effect of human feeding on the road mortality of Rhesus Macaques on National Highway-7 routed along Pench Tiger Reserve, Madhya Pradesh. Sharma *et al*. (2011) studied man-monkey conflict and its management in Jodhpur, Rajasthan. Imam and Ahmad (2013) studied the population status of Rhesus monkeys in Aligarh and their menace which is a serious threat for its future conservation. Uttar Pradesh State Action Plan on Climate Change (2014) reported the nine agro-climatic zone of U.P. Ganguly *et al.* (2018) assessed human-monkey conflict and its mitigation strategies in Delhi. Sengupta and Radhakrishna (2018) analyzed mutual influence of Humans and Rhesus macaques due to availability of food availability in the buffer zone of Buxa Tiger Reserve in West Bengal. Ganguly and Chauhan (2018) elucidated behavioral activity patterns and reproductive

ecology of urban Rhesus macaques in human dominated landscape of Delhi and its implication in management.

2.3 Need of the study

Review of literature reveals that work has been done on Human-Macaque interactions but there are no holistic studies on the cognitive ethology of macaques, especially inter-specific interactions in urban areas of the semi-arid zone. Deforestation and urbanization have provoked the populations of monkeys to foray towards the urban areas which may have influenced the behavior of macaques. Only manual observations have been conducted so far. There are isolated records of quantitative behavior analyses. Till date, use of modern technology like behavior coding software for hypotheses testing of Rhesus macaques has not been reported. According to Department of Environment, Government of Uttar Pradesh (2014), Semi-Arid zone is one of the nine agro climatic zones of Uttar Pradesh. In this zone, Rhesus Macaque populations have been frequently spotted in and around its urban areas, especially along highways (Personal Observation). Therefore, the present study has been designed to assess all behavior activity patterns, interspecific interactions and cognitive skills of *Macaca mulatta* across all seasons at urban areas of Semi-Arid zone of Uttar Pradesh.

3. Objectives

1. To study and identify the behavior, cognition and interactions (inter-intra specific) of *Macaca mulatta* in urban areas of Semi-Arid zone of Uttar Pradesh.
2. To analyze the impact of *Macaca mulatta* behavior, cognition and interactions on humans as well as non-human species.
3. To develop an action plan for the benefit of *Macaca mulatta*, urban wildlife and Human society.

4. Hypotheses

Following hypotheses have been formulated for the present study:

Null Hypothesis (H_{01}):- There is no significant difference in the behavior, cognition and interactions (inter-intra specific) of *Macaca mulatta* in the selected urban areas.

Alternate Hypothesis (H_{A1}):- There is significant difference in the behavior, cognition and interactions (inter-intra specific) of *Macaca mulatta* in the selected urban areas.

Null Hypothesis (H_{02}):- There is no significant impact of *Macaca mulatta* behavior, cognition and interactions in urban areas on humans and non-human species.

Alternate Hypothesis (H_{A2}):- There is a significant impact of *Macaca mulatta* behavior, cognition and interactions in urban areas on humans and non-human species.

5. Methodology

It is a non-invasive observational study and therefore does not require any ethical approval.

5.1 Sampling sites

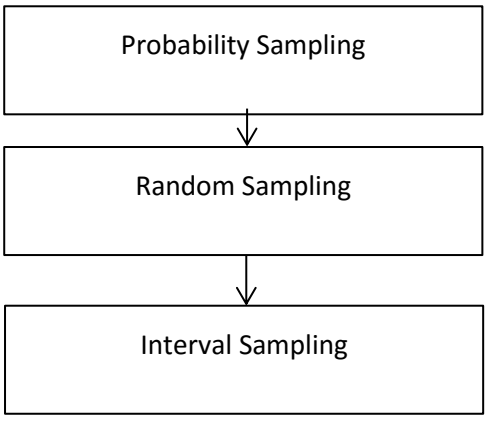
Fig. 1 depicts urban areas of Semi-Dry Zone of Uttar Pradesh which are as follows:

1. Agra
2. Aligarh
3. Etah
4. Firozabad
5. Hathras
6. Mathura
7. Mainpuri

   (Some target areas identified during pilot studies- railway stations, road sides, markets, residential areas and temples)

5.2 Sampling methods

Random sampling will be deployed because the Rhesus macaques are free ranging mammals and presence of any individual at a given place and time cannot be predicted.



5.3 Behavioral sampling techniques

The following sampling techniques will be employed-

1. Focal sampling technique (Martin and Bateson, 1993)
2. Scan sampling technique (Altman, 1973)
3. *Ad-libitum* sampling (Altman, 1973)

Activities of each individual will be observed and recorded on the respective data sheets. Each activity will be assigned a particular code to make the recording of data convenient.

Each field observation of an hour will be divided into four sampling periods of 15 min. each (observation period of 10 min. with 5 min. interval to prepare for next observation period).

5.4 Sample size

Primary data collection:

(A) Human respondents: Primary data collection will be done in the form of self-framed questionnaire perceived to assess the impact of *Macaca mulatta* behavior on humans. Based on Godden's formula for infinite respondent population, approximately 400 respondents from diverse sections of urban areas will be approached.

(B) Target animals: There is no latest documented information on the population trends of *Macaca mulatta* at selected sites, therefore the sample size cannot be predetermined. However, attempts will be made to discriminate between individuals on the basis of individual specific morphological ID marks/subtle details of body size, location, territory, partner, gender, facial/ body marks and stance.

Location of monkeys through GPS would be imposed on the area maps with help of GPS Tracker software and if possible, use of satellite images to track their movements and to see their distribution pattern will also be done.

5.5 Observation schedule

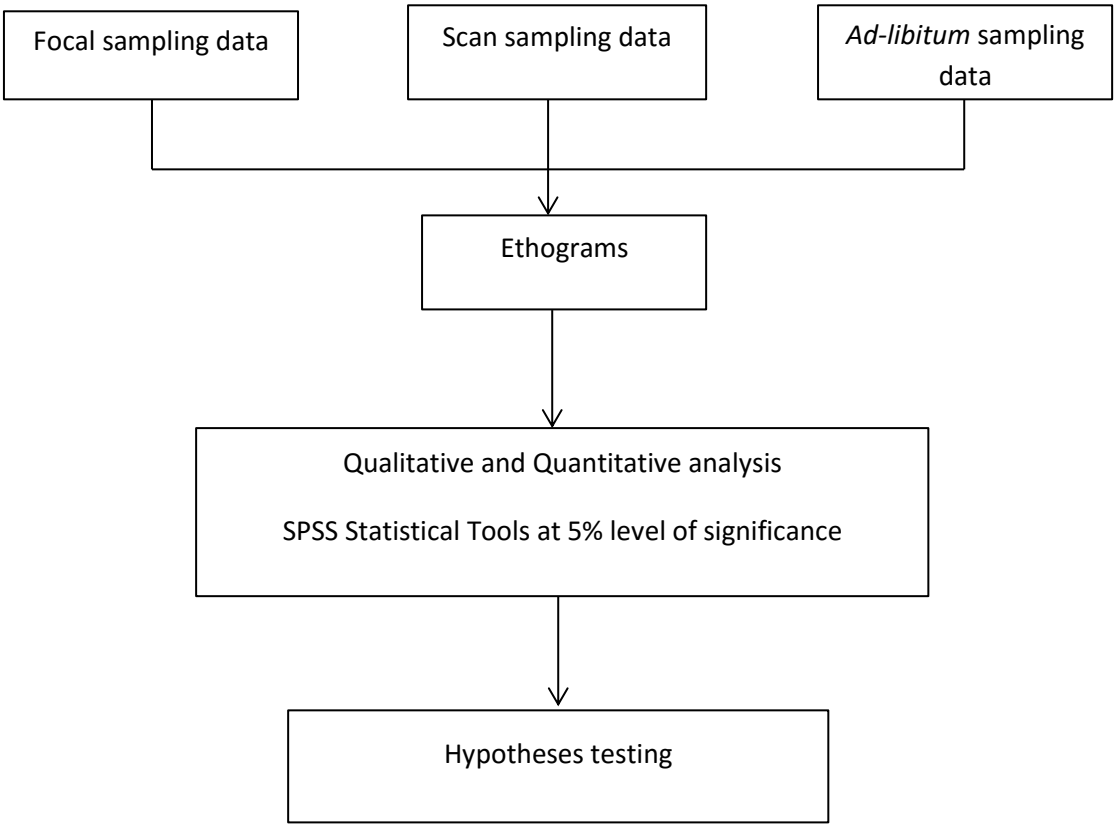
- The observation schedule of the study will be 6 AM to 12 Noon and 5 PM to 7 PM
- Observations will be taken throughout the year, comprising of weekly visits at each urban area.

5.6 Tools and Equipments

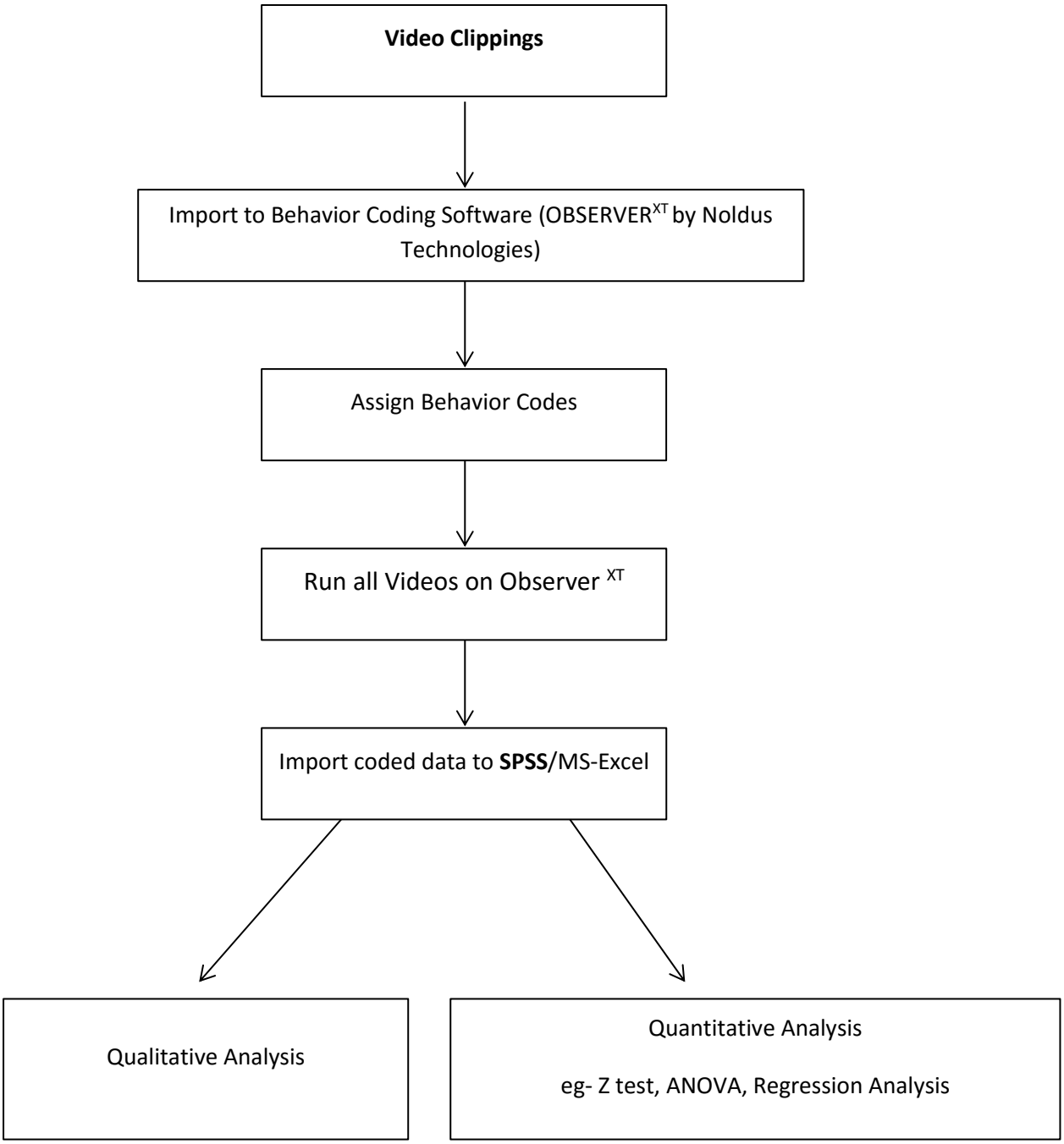
1. 35X optical zoom camera for still photography and videography.
2. Notepad
3. Stopwatch
4. Field audio recording device
5. Bio-acoustic analysis software (MATLAB)
6. Behavior coding software (Observer ^{XT} by Noldus Technologies)
7. Binoculars 8-16X 40 zoom DPS I field 5.0-3.4° with UV protection
8. GPS tracking device and GPS tracker software

6. Data Interpretation

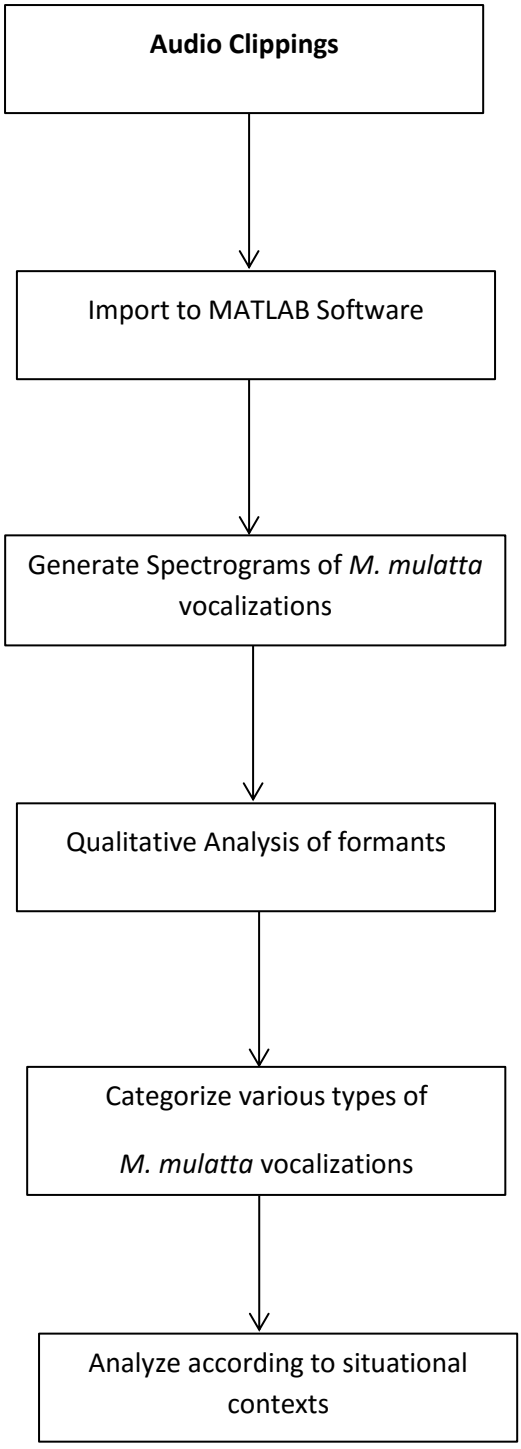
6.1 Manual Observations across 5 seasons – spring, summer, monsoon, autumn, winter



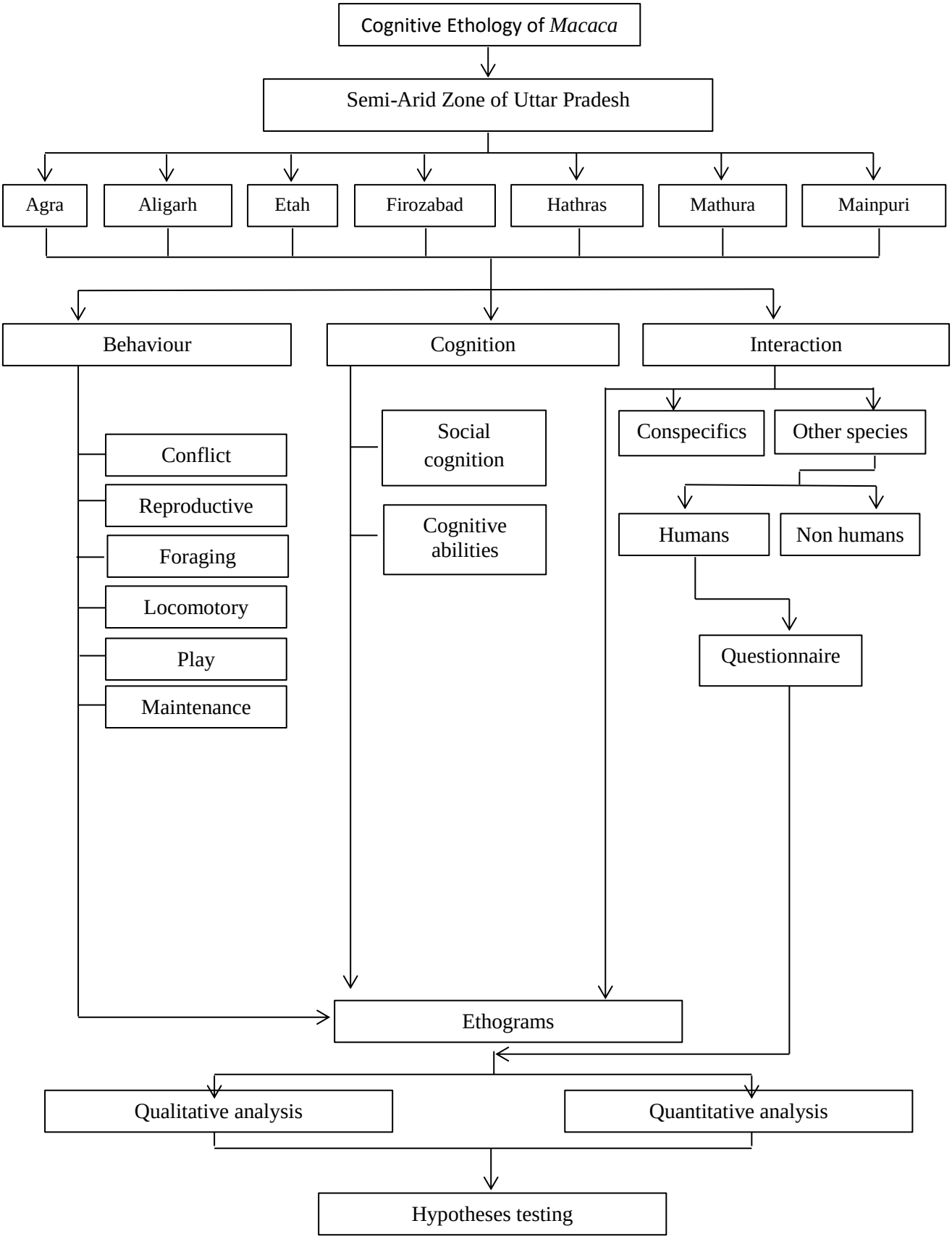
6.2 Video clippings

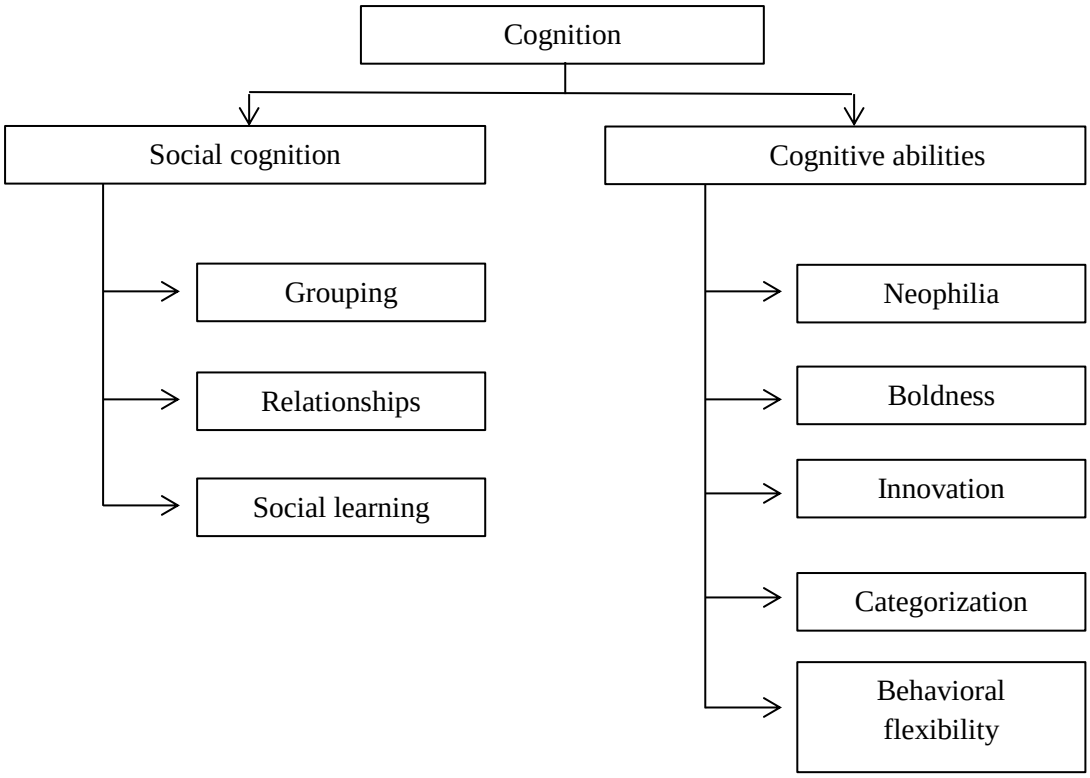

Video Clippings
Import to Behavior Coding Software (OBSERVER XT by Noldus Technologies)
Assign Behavior Codes
Run all Videos on Observer XT
Import coded data to SPSS/MS-Excel
Qualitative Analysis
Quantitative Analysis
eg- Z test, ANOVA, Regression Analysis

6.3 Audio clippings


Audio Clippings
Import to MATLAB Software
Generate Spectrograms of M. mulatta vocalizations
Qualitative Analysis of formants
Categorize various types of M. mulatta vocalizations
Analyze according to situational contexts

9. Plan of Work




Cognition
Social cognition
Cognitive abilities
Grouping
Relationships
Social learning
Neophilia
Boldness
Innovation
Categorization
Behavioral flexibility

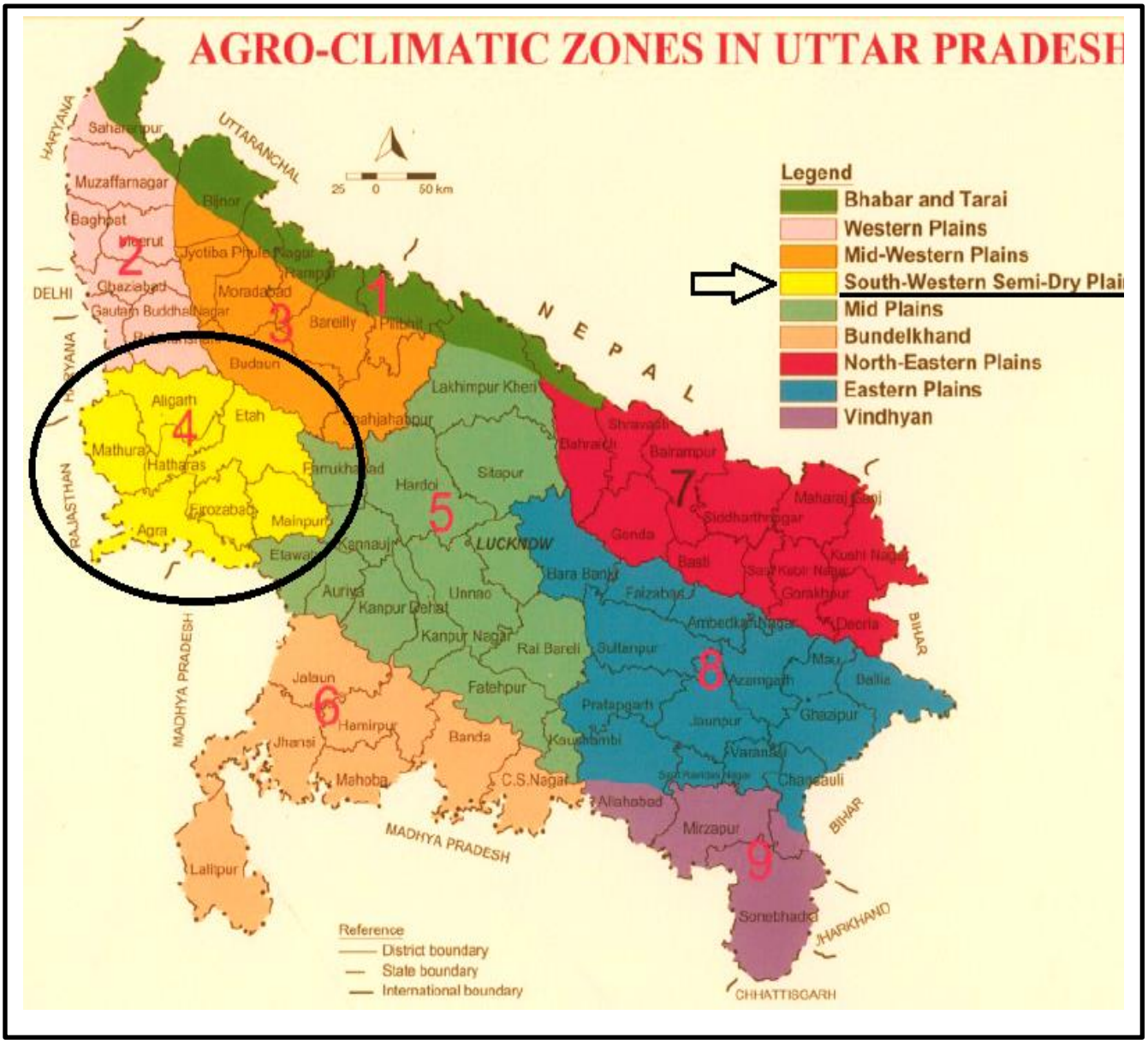


Fig. 1: Map showing Semi-Arid zone of Uttar Pradesh

(Source: Uttar Pradesh State Action Plan on Climate Change, 2014)

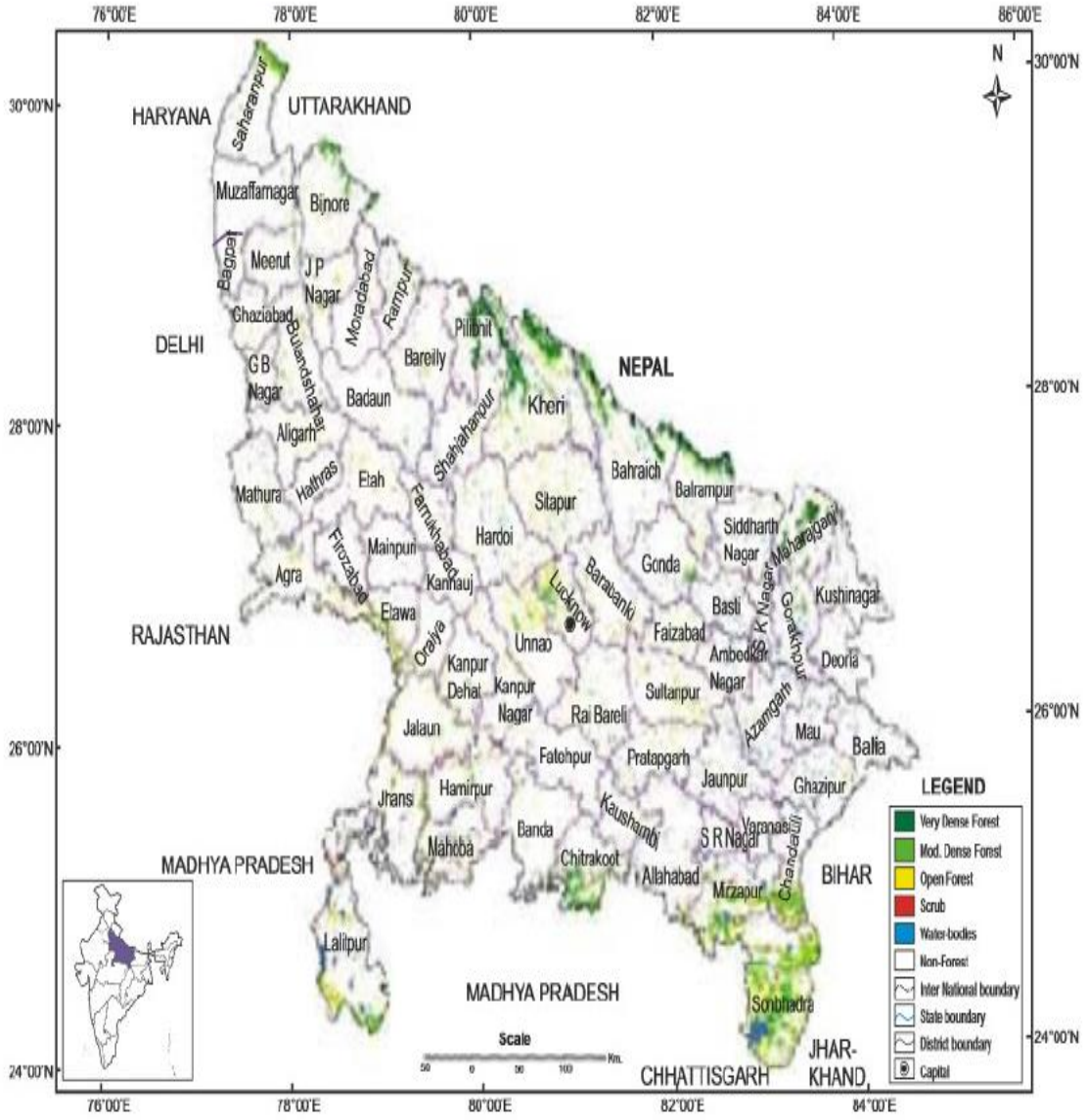


Fig. 2: Map showing Forest Cover map of UP (source: State Action Plan on Climate Change UP, 2014)

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